Dundee Canal: Headgates, Guardlock, and Uppermost Sections
250 feet northeast of Randolph Avenue, opposite and in line with East Clifton Avenue
Clifton
Passaic County
New Jersey

HAER No. NJ-45

HAER
NJ,
16-CLIF,
5-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
MID-ATLANTIC REGION, NATIONAL PARK SERVICE
DEPARTMENT OF THE INTERIOR
PHILADELPHIA, PENNSYLVANIA 19106

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Location:	250 feet northeast of Randolph Avenue, opposite and in line with East Clifton Avenue Clifton, Passaic County, New Jersey UTM: 18.573550.4525870 Quad: Paterson, New Jersey
Date of Construction:	c. 1833 (part of canal prism only, c. 1858-60 Modified in c. 1870, c. 1899-1903, c. 1903-36, 1974-78
Engineer:	Joseph W. Allen
Original Builder:	Joseph Scott
Present Owners:	(each with half interest) United Water Resources, Inc. 200 Old Hook Road Harrington Park, New Jersey 07640 North Jersey District Water Supply Commission 1 F. A. Orechio Drive Wanaque, New Jersey 07465
Present Occupant:	Under management of the Hackensack Water Company, until just prior to field documentation
Present Use:	Vacant
Significance:	The Dundee Manufacturing Company built the present Dundee Dam and the 1.8-mile Dundee Canal between 1858 and 1861, culminating at least three decades of attempts made to harness Passaic River water power at the dam site, and over six decades of planning for navigation between the Great Falls at Paterson and tidewater at Passaic. Paterson's older but analogous Society for Establishing Useful Manufactures was an apparent parent of the Dundee venture and corporation. The dam and intake structures at the canal's upper end were the most substantial and important features of the short system. Although designed for an unusual combination of navigation and power, the canal and its builders proved incapable of sustaining the former of its two principal chartered

roles, and after two corporate reorganizations, the company emerged in 1872 as the Dundee Water Power and Land Company. As a seller of water rights for power and processing, the new company and its facilities were pivotal in the transformation of the small tidewater junction of Acquackanonk into industrial Passaic, a national center of integrated woolen production whose growth yielded the company more income from real estate sales until the late 19th century. Despite the exhaustion of available land rights, increasing use of steam or electric power by canal-side industries, and decreasing availability of clean canal water for woolens processing in the 20th century, the company' lake, dam, and canal continued to provide a stable corporate income in water rights leasing for fire prevention and non-woolen industrial production. Rubber products manufacture emerged as a major local industrial component by the early 20th century with less stringent water quality requirements than woolens, and survived the contraction and disappearance of woolens production between c.1929-59. Canal appearance and ownership began a series of changes in the 1930s, as the city of Passaic flumed over much of what had become an aqueous corridor of trash. The canal's owners sold out to a group of local lawyers shortly after World War II, in a move linked to the demise of the Society for Establishing Useful Manufactures. A sequence of related public water supply corporations gained control after 1974, resulting in the demolition and stabilization of deteriorated elements at the canal's upper end. Until 1985, however, the guardlock and headgate structures built in tandem at the dam's west end retained much of their original configuration and features, and had additional significance as the most dramatic visual vestige of the dual navigation-power functions projected by the canal's first proponents. Nearby prism sections also have archaeological significant in the apparent retention of data on the sequence of canal construction below the dam site, beginning with the earliest such episode in the 1830s.

Project Information: American Hydro Power Co., in compliance with a Memorandum of Agreement with the Federal Energy Regulatory Commission and the Advisory Council on Historic Preservation, funded documentation of the upper end of the canal system, leased by the company for a hydroelectric facility. Construction in late 1985-early 1986 removed all remains of the east canal bank below the guardlock and all intake gates, modified the eroded west canal bank, and removed half the west guardlock wall for installation of a fish diversion louver/trashrack. Field documentation took place in October and November 1985, with other research and writing conducted between February 1985 and March 1986.

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PART I: HISTORICAL INFORMATION

Origins of the Dundee Canal, 1791-1858

The Dundee Canal and its local predecessors represented the development of the lowest and probably the latest hydropower site on the Passaic River, taking some of the approximately 40-foot drop on the river between the foot of the Great Falls at Paterson and the head of tidewater at present Passaic. This section of the river was generally gentle in its original post-glacial state, and the short, low rapids marking the 19th century Dundee Dam site did not immediately attract the large and small mill developments seen at higher points in the Passaic drainage beginning early in the 18th century. Beginning late in the 18th century, regional industrial development focused between Great Falls and tidewater defined the origins of the canal and Passaic, although the canal, completed in c. 1861, physically reached only the lower end of this reach. Paterson's earlier emergence at the falls as a major industrial center encompassed the first plans for a combined navigation and power canal system reaching tidewater, and at least some of the later corporate organization and ownership of the Dundee Canal (Whitehead 1901: 10-13; Fries 1974; Brydon 1974: 127-53).

When the process of site selection and water control system planning by the Society for Establishing Useful Manufactures (SUM) began in 1791, Great Falls was a scenic wonder with far less regional importance than the head of tidewater at the village of Acquackanonk, where a Dutch farming center and important transshipment point for upriver settlements had grown from the late 17th century. During SUM consideration of alternatives for industrial and hydropower sites, at least two plans emerged which, for the first time, suggested Acquackanonk as a manufacturing center. The most ambitious, proposed by one SUM corporate faction in 1791-92, involved a combined transportation and power canal from a point above Great Falls to Acquackanonk, with the SUM mill sites to be developed on tiers of raceways near the canal's lower end. This plan apparently sought simultaneously to capture most of the 115-foot fall from the head of Great Falls to tidewater, to eliminate industrial transshipment problems by concentrating factories at the head of Passaic River navigation, and to streamline and capture the traditional traffic between the upper and lower Passaic. Although the SUM eventually rejected this plan in favor of development at Paterson, some SUM proponents began land purchases in the Vreeland's Point area on the river immediately above Acquackanonk Landing. Probably stimulated by both this particular possibility as well as the widely publicized SUM site search, some Acquackanonk and other local men suggested a second early plan in 1792--also unrealized--for a short power canal from present Dundee Dam to an industrial center in the village vicinity (Figure 2; Scott 1922: 263; Fries 1974).

The relationship between these two plans and their proponents remains unclear, but the SUM site search and selection of Paterson highlighted for the first time three paramount aspects of later Dundee Canal development: the head of Passaic River navigation as both the lower limit of industrial waterpower development and the upper limit of inexpensive water transport to any such development above Acquackanonk; the development of Acquacknonk or Vreeland's Point as an industrial center; and the use of the Dundee Dam site to power this potential center. With the eventual success of Paterson and the SUM, beginning in the 1820s, there was renewed interest in these possibilities on the varied parts of Paterson and other upriver manufacturers facing transshipment costs, Acquackanonk men seeking to tap Paterson's growing need for lumber and grain, and capitalists from Paterson and elsewhere in the region anticipating secondary cotton cloth processing growth around the Great Falls nucleus. It took over forty years for the Dundee Canal to emerge as a profitable source of power and processing water rights, with a deliberately vague role as a navigation canal, after a series of unsuccessful plans and false starts.

There were at least four stages in this emergence, three of which began prior to construction of the completed Dundee Canal between 1858 and 1861. The earliest involved local attempts to tap the Passaic River's power at the Dundee Dam site for a small grist and saw mill complex on the east or Bergen County side of the river. One or more undocumented wing dams here, dating to the late 18th or early 19th century, preceded the first known plan to dam the entire river n 1828, when the dam and mill owners, led by John S. Van Winkle and Jacob Van Blarcom, secured a right from the State legislature to create such an impoundment. (An earlier dam here could have inspired the 1792 plan to power mills at Acquackanonk from this site.) These men did little more than rebuild and enlarge existing facilities, raising the wing dam without spanning the river. In 1832, they sold their rights, lands, and improvements to Jacob Van Winkle, another local man acting as agent for, or anticipating a quick sale to a group led by upriver manufacturers from Pompton. They bought out Van Winkle the following year, after incorporating the Dundee Manufacturing Company (DMC) in 1932. With the second purchase, local or Acquackanonk control of Dundee dam and canal development ceased, fatally wounded by lack of capital and, perhaps, breadth of vision (Clayton 1882: 379; Scott 1922: 263-65, 269).

The next two stages correspond to the two principal charters of the DMC, granted by the State in 1832 (amended to allow development on the west side of the river in 1833) and in 1858 when, for the first time, the company was empowered to develop navigation. In outline, the story of the DMC in secondary sources is simple. However, the source, nature, and intent of the several plans involved remains shrouded in the unwritten corporate histories of the DMC; its successor, the Dundee Water Power and Land Company (DWPLC); the SUM of Paterson, and an ephemeral corporation called the Passaic

Navigation Company. At some point, ownership of the SUM and the Dundee Canal evidently converged, remaining essentially one set of interests until after World War II (Anonymous n.d.: 4-6). Explaining the unusual place of navigation in Dundee Canal history probably requires unraveling the interests behind the project at different times, a research effort at best uncertain and to date never really attempted. Surviving written records of the DMC and DWPLC are extremely limited--many having burned early in the 20th century--making informed conjecture nearly as important as evidence.

During the second documented stage of development in the 1830s, the Pompton-based iron and barrel manufacturers who obtained the charter built the first dam across the river at the Dundee site in c.1833, along with a 12-foot-deep, half-mile-long canal along the course of the present one to power two grist mills around later President Street in Passaic. This venture, which apparently continued the Bergen County sawmill operations, was probably similar in scope to the earlier projects at the dam site in its emphasis on traditional rural industry with anticipated new urban markets. The Pompton-based DMC attempted for the first time to weave another of the SUM-stimulated possibilities into development plans, by shifting to the west side of the river and hoping for industrial growth in the Acquackanonk area. The SUM had indirectly encouraged such expectations by promoting the Paterson and Hudson River Railroad through Acquackanonk to Jersey City, a line completed in 1831 which eliminated the old landing's transshipment role and offered better links with New York City. Timber and grain processing did not sustain the early DMC, however, and its operations ceased in a few years after the local timber supply disappeared. The lack of both a more diversified industrial base and a direct water or rail link to and from the short canal to Acquackanonk again inhibited development (Scott 1922: 265, 269; Kenyon 1960: 31-2).

The third stage is essentially the story of varied attempts to combine navigation and water power on the Dundee Canal, beginning in the mid-1830s, culminating in the construction of the present canal system beginning in 1859, and ending with the failure and reorganization of the DMC between 1864 and 1872. The fourth and last stage, after 1872, saw the DWPLC profit by selling land and water rights while eliminating navigation from further consideration. The navigation plans made prior to 1858 centered on linking Acquackanonk and Paterson with a system combining an artificial canal with slackwater Passaic River travel. Despite Paterson's growing rail connections, movement of raw cotton into the city by water from southern States remained an attractive possibility until the 1850s, by which time Paterson's cotton cloth making was in decline and rail links were too developed to make new waterways competitive. Industrial possibilities for a projected Dundee Canal included cotton cloth manufacture--still an attractive venture in this region during the 1830s--and use of Passaic River water for cotton bleaching and other finishing processes requiring clean water, by then a diminishing feature of Paterson's water resources.

There were apparently two groups involved in promotion of a combined navigation-power system during this stage: a group of Trenton and Philadelphia developers led by Edward J. C. Atterbury, usually credited with the earliest ideas for the Dundee Canal system as later built; and the SUM, which owned all DMC assets from 1850 to 1858 and, at some point, probably before 1872, gained control of the canal system built 1858-61. The Atterbury group, assisted by engineer Joseph W. Allen of the Camden and Amboy Railroad, evidently made the first detailed plans resembling the Dundee Canal in the mid 1830s, but was unable to obtain both a charter empowering navigation and the land needed for a canal until 1858. The first charters issued by the State allowing a Dundee Dam impoundment, in 1828 and 1832-33, left navigation development rights with the State, to preclude any Passaic River-tidewater connections from the Bergen County side of the river. Although not so stated in available sources, it is possible that the SUM lobbied for this restriction to retain its potential interest in a water and/or hydropower link with Acquackanonk. The first State charter for navigation between Paterson and Acquackanonk using Dundee Dam appeared in 1836, granted to the Passaic Navigation Company. Whether this corporation represented Atterbury's group, the SUM, or some third group remains undocumented, but with the DMC retaining at least some of the assets and rights required to complete such a system, the new company produced only a map of its intentions which evidently included an entirely artificial canal with a lock at its lower, Passaic River end (Scott 1922: 253, 263, 266).

The SUM purchased all DMC assets in 1850, but made no further improvements during the ensuing eight years of direct SUM ownership. Defining reasons for this inaction, or unraveling relationships during this period with SUM, the Atterbury group and the Passaic Navigation Company must await additional research. Declining Paterson cotton production and improved rail links may explain some disincentives towards canal construction. By this time, the Passaic Navigation Company had disappeared from public notice. In 1858, the Atterbury group purchased the DMC from the SUM, and at about the same time obtained a supplement to the original DMC charter empowering navigation improvements between Paterson and the mouth of Weasel Brook in Acquackanonk or Passaic Village by way of one or more canals and/or slackwater navigation. Atterbury became president of the new DMC. Plans soon presented by the DMC, outlined below, probably duplicated or followed closely the 1830s plans of Joseph Allen, who now became chief engineer as well as a company director. The new charter had several other significant provisions: it created a mechanism for the DMC to condemn lands for canal construction, based on the presumed public benefits of creating a public waterway, but imposed no time limits for beginning or completing such work. Atterbury's first report to the stockholders, issued in June 1858, stressed the value of potential building lots on about 340 acres purchased by the DMC over a previous undocumented period, and of potential milk sites with docks on both tidewater and the navigable headrace, accessible to various points in the region by tidewater, railroad, or turnpike. In this report, navigation tolls, regulated and prescribed by the charter, appeared as a secondary and more remote source of income from eventual upriver bulk products traffic in lumber, bricks, lime, and coal which otherwise required transshipment to rail. What the report did not note was that supplying Paterson with raw cotton was no longer a viable vision and that, at best, canal traffic was a means of moderating rail freight rates through potential competition. The company's stated goals emphasized industrializing the village of Passaic (formerly Acquackanonk), with its navigation mandate providing a ready means of acquiring the land immediately needed for canal construction. Although the unwritten story of the legislative influence required to amend the charter and of arrangements between the two canal proponent groups may provide a fuller of the intentions behind the Dundee Canal, this report remains a telling forecast of the canal as built. The project proved to be an unusual and initially unsuccessful one in which navigation played little part, but it eventually proved profitable in Atterbury's terms, as a purveyor of land and water rights (Dundee Manufacturing Company 1858: 6-17; Scott 1922: 266-68).

Planning, Construction, and Initial Operation of the Dundee Dam, 1858-61

With its amended charter, the DMC moved quickly to complete canal system plans, attract additional capital, and begin construction. The first work on the new Dundee Dam began in April 1859, twelve months after the new stockholders and directors repurchased the company from the SUM, and fourteen months after issuance of the charter. This relative alacrity reflected Allen's prior planning and the principal stockholders' capital contributions of some $150,000. Allen had two sequential plans to develop the full 40 feet of river fall he measured from below Great Falls to tidewater. His first, preferred proposal, the only one completed, involved rebuilding and raising the existing Dundee Dam eight feet to create a 22-foot head and fall from a 250-acre reservoir at the lower end of the reach, and extending and enlarging the existing half-mile canal along its present course. His second, unbuilt proposal involved developing the uppermost 18 feet with a dam about two miles above Dundee Dam and a canal on the west river bank to the latter site after completing the lower dam and canal project. Dam heights noted in Allen's report and in Scott's account (1922: 269) require extreme caution in any historical reconstruction, since they confuse falls to tidewater with heights from dam crest to dam toes. The present Dundee Dam was originally 13 feet high, later increased to 18 feet, not the 22 feet given by Scott; the latter figure would put the dam toe about nine feet below the original bedrock river bottom (Lindsey 1875; Works Projects Administration 1936 [drawings], reproduced as Photograph 17.) The dam of 1859 evidently had a crest eight feet higher than the dam of c.1833, but the actual heights of the timber and stone dams built c.1833 or earlier are otherwise unknown.

The canal system as built was simple, with a main canal or headrace about 1.8 miles long, delivering about two feet of head, and a 1500-foot kong lower canal or tailrace over 24 feet below at approximate tidewater elevation, in the channelized lower end of Weasel Brook to the west (Figure 1). All potential mill sites encompassed the ell-shaped lower headrace below the junction with the lower canal, since this was the only section where fall to tidewater in Weasel Brook or the Passaic River could provide effective mill rights. Weasel Brook, more or less paralleling the canal in present Clifton and Passaic, was an important local source of pure water for cotton bleaching, with existing mill privileges. Allen's plan did nothing to interfere with these privileges, since there were no structures built in the brook which interrupted the flow, despite the fact that Weasel Brook was intended also as the navigation link between tidewater and the reservoir (Dundee Lake). A flight of two locks was designed to join the upper and lower canals, but Allen planned no lock at the mouth of the brook to assure a navigable level of water in all tidal conditions. The only other original canal structures were the masonry dam and intake structures built by Joseph Scott, as described in Part II, a flume at the lowest end of the upper canal entering the river, and possibly a similar flume directly west, where the canal makes its 90 degree turn.

After completing the dam and intake structures in 1859-60, the DMC apparently built the remainder of the system from north to south in 1860-61, reusing and probably widening the earlier canal prism, extending the earlier canal in shallower form to complete the upper canal, and excavating in lower Weasel Brook for the lower canal. The uppermost structures were the most substantial components of the system, probably attesting to the increasingly dire financial condition of the company as construction progressed. With an impending or actual Civil War inhibiting new cotton manufacturing investments, and resistance of Vreeland's Point farmers to additional DMC land purchases, the company sold no lots or mill rights prior to the opening of the canal in July 1861, completing the system, which cost about $300,000, with a diminishing capital fund and a mortgage on company assets. Some of the mortgage money probably went towards two large farm purchases rather than more substantial engineering structures. The canal system proved to be unnavigable. Although one boat is said to have passed through the canal and locks, the lower locks were never entirely completed and the guardlock at the dam lacked a lower gate, making it unlikely that any vessel ever made a complete trip between Dundee Lake and the Passaic River. In the context of an increasingly dense rail network, there was little demand for navigation, at best anticipated by the DMC as its least profitable service or resource. The company allowed much of the system to deteriorate, as repair bills eroded what was left of available cash. Rather than invest any more in the lower locks, the DMC filled in most of this site, leaving the lower canal available only for tailrace purposes. After unsuccessfully opening a foundry on the canal to stimulate manufacturing interest, by 1862 the company was essentially at a standstill, facing a perilous financial future (Clayton 1882: 381-82; Commission to inquire...1912: 5; Scott 1922: 270-71).

The canal system completed in 1861 remained essentially unchanged until the mid-1930s, except for the gradual addition of undocumented intakes to private user sites later in the 19th century, and the increasing filth and debris which filled much of the system by the early 20th century. This mid-19th century system was highly unusual in being an attempted transportation and power canal, and in being a very late example of a private American canal corporation. Since DMC navigational intentions were, at best, ambiguous and the technical quality of DMC engineering highly uneven for navigation purposes, the feasibility of navigation above Passaic River tidewater remains a moot point, but the water impounded by Dundee Dam nearly always exceeded the amounts required for leased rights and might have encompassed both original canal functions. There were few, if any, examples of successful fully-combined systems among earlier American canals. Public navigation on power canals was a minor component of the system at Lowell, where the traffic volume was too low to conflict with power requirements. When canal traffic and power use were both more substantial, as on the Blackstone Canal system in Rhode Island and Massachusetts, the water needed for lockage and the surges created by boats led to legal challenges by mill owners. The Enfield Canal in Connecticut, a navigation system with ancillary sales of mill rights, was unusual in accommodating both needs, but probably because railroad competition quickly diminished traffic, leaving the increasingly important power users on the canal undisturbed. It remains unclear if DMC proponents thought through problems of combined system use, or simply assumed that if their navigation system succeeded, it would be a minimal component presenting few problems of power interruption (personal communication, Patrick M. Malone; Cumming 1978; Clouette 1975).

The Rise and Success of the Dundee Water Power and Land Company, c1862-1900

The DMC entered receivership in 1864, and after several years under the reorganized management of Atterbury, he and his group finally sold out in 1869 to unidentified purchases probably associated with, or identical to, the SUM. As the company foundered, however, conditions improved for realizing Atterbury's final vision of a land and water right company with no navigational expenses, and his dying DMC arose to become "..the mother of Passaic industries.." (Scott 1922: 265). Civil War demand for shoddy and other woolen products, together with the search by regional cotton printers and bleachers for cleaner water and lower wages than were available in Paterson, contributed to the area's development. Beginning in 1862, Paterson's growing silk industry's labor costs helped drive out woolen and cotton processing and combined to bring manufacturers to the Dundee Canal. Although such establishments were too few and too late to save the Atterbury group, by the end of the decade it was clear that Passaic would finally grow from a small village of several hundred people, as it was when canal construction began, into an urban industrial center. The reorganized DMC secured additional bonding authority, a change of name, and the right to build a rail spur to the Paterson & Hudson River line (part of the Erie system) from the State in 1872 to take advantage of increased opportunities, probably incurring more debt to buy more land on the promise of its five occupied mill lots. Responding to early industrial growth, and anticipating more, local residents succeeded in setting off Passaic as a village within older Acquackanonk township in 1869, and obtained a city charter in 1873. Paterson interests, also sensing the change, set up the Acquackanonk Water Company in 1867 along Weasel Brook above the tailrace, tapping both the brook and the Dundee Canal headrace for supply, and also probably using the latter to power a pump (Clayton 1882: 382; Pape and Scott 1899: 75, 279-81; Whitehead 1901: 234; Scott 1922: 136, 270; Kenyon 1960: 49-50; personal communication, Edward S. Rutsch).

By 1880, Passaic was an integrated woolen center of increasing national importance, with facilities for weaving, dyeing, bleaching, and processing of waste products and several important cotton printing and bleaching works. Most of these operated along the lower canal headrace, above and below the right angle near the river. In 1881, The Dundee Water Power and Land Company hastened development by building its rail spur to the Erie's Bergen Branch across the river in Garfield rather than to the main line through former Acquackanonk Landing, and operated it briefly before ceding control to the Erie. This venture eliminated most needs for cartage in the growing Dundee district, an area which became an even more concentrated woolens center after the New York, Susquehanna, and Western Railroad built a spur from the north which, with the Erie connection, created a rail loop. In c.1890-1900, larger integrated woolens manufacturers, the Botany Worsted Mill and the Gera Mill, began moving to the Dundee district from Germany, in response to federal woolens tariffs decisions, locating off the canal or above points on the system where waterpower was available. These later companies highlighted the decreasing importance of water power and the increasing importance of process and fire protection water, in the value and use of DWPLC mill rights. Similar shifts in water use on the canal characterized the establishment of rubber products manufacturers after 1882. The varied industrial water use systems developed privately off the Dundee Canal remain largely undocumented (Pape and Scott 1899: 279-86; Scott 1922: 260; Kenyon 1960: 49-56).

Dramatic residential growth accompanied Passaic's industrialization. The city's population of some 25,000 in 1900 was about nine times the size of the village in 1870 and continued to soar until 1920. During the decade following 1880, the increase of both industry and population was sufficient to create a strong market for DWPLC real estate, on which the company had been sitting for years. Concentrated east of the canal in Vreeland's Point, on Dundee Island in the river, and west of the canal above the city waterworks and Vreeland Pond on Weasel Brook, these lands when sold released the company from its last bonded indebtedness by 1892. Residential development and massive trash disposal led to elimination of the channel between the island and the city about this time,, and the company sold its rights on the island to a residential development company in 1894. With the cessation of most new land sales late in the century, the DWPLC became a stable and static financial enterprise based on water rights rentals (Clayton 1882: 382; Pape and Scott 1899: 75; Scott 1922: 35, 270-71; Kenyon 160: 55-6).

For reasons never fully explained in available sources, the company's success prompted varied combinations of landowners above the dam or formerly along the canal, some bulk products users, and politicians in Paterson and Passaic to call for completion of the original DMC navigation project, in a sporadic series of legal and legislative actions between c.1881 and 1922. Manufacturers in Passaic or Paterson expressed little, if any, interest in river traffic. The company fended off all such challenges, chiefly by noting the lack of market demand for navigation and the lack of any time limits on the navigation mandate set forth in the 1858 charter supplement. When navigation proponents succeeded in obtaining federal studies of the river for possible Corps of Engineers projects, the company professed a willingness to surrender its navigation rights, provided the State or federal governments bore all construction costs and protected the company's mill rights. Although no new navigation systems resulted from these four decades of controversy, surviving DWPLC drawings suggest the company prepared designs for completing the missing lockage components in its system during some of these battles, perhaps to demonstrate its ability to provide navigation, if economic demand warranted such investment. Except for minor work at the intake structures and some dam repairs, however, the DWPLC evidently made few, if any, changes to the system completed in 1861 (New Jersey State Supreme Court 1882; Dundee Water Power and Land Company 1918, n.d. [drawings]; Scott 1922: 271-72; Anonymous n.d.).

Corporate Changes, Public Control, and Public Water Supply c1900-1985

Passaic industries continued their 19th century growth trajectory until the 1920s, with new woolens and paper manufacturers moving north along the canal until c1910, reaching Ackerman Street in Clifton, the Acquackanonk Township village that grew rapidly as a satellite of Passaic in the early 20th century to become a city in 1917. Replacement of dirty canal water with more expensive public water supplies, decreasingly competitive labor costs, and increasingly antiquated equipment contributed to the long decline of Passaic textile manufacturers between 1929 and 1959, leaving most such establishments or their successors on the canal using DWPLC water only for fire protection. The Passaic area's industrial diversity, however, and new growth in rubber and paper products manufacture until about World War II, helped the Dundee district weather the depression of the 1930s and continued a demand for non-textile process water from DWPLC sources. While these changes in twentieth century Passaic industries affected the nature of Dundee Canal water use and water users. The DWPLC mill power leases, some extremely long and all based on a system of priorities created in 1865, continued to provide enough water for all users and for all purposes despite the increasing deterioration of the canal facilities. The supply in Dundee Lake was adequate not only for canal-side users, but eventually served paper manufacture drawing water directly from the lake as well (Dundee Manufacturing Company 1865 [primary sources]; Sanborn Map Company 1910; Kenyon 1960).

With a limited but stable income, the DWPLC collected its rents and made as few improvements as possible. Devastating Passaic River floods of 1902 and 1903, or perhaps a contemporary suit on DWPLC navigation responsibilities, prompted rebuilding of the guardlock gates as documented in Part II below. This and other limited work at the same site apparently encompassed most of the maintenance or repair done on the canal prior to the 1970s. As the canal became increasingly filthy and debris-laden, a perceived hazard to local children, and a potential surface for municipal development, the city of Passaic took advantage of available Works Progress Administration labor and leased the canal surface from the DWPLC in 1935, installing a double concrete flume or culvert in about 2200 feet of the canal north of Passaic Street. The city developed municipal parking and other limited public space on the new solid surface (Herald News June 29, 1950; Anonymous n.d.).

Control of the DWPLC by the SUM of Paterson ended when the parent corporation sold out to the city of Paterson during World War II. After a brief period of rapid transfers through New Jersey General Securities Company, a group of investors led by the local law firm of Greenburg, Wilinsky, and Feinburg purchased the DWPLC in 1946. The new directors continued to collect rents and ignore maintenance. In 1974, potential use of DWPLC assets for public water supply attracted the Hackensack Water Company to purchase the company, after detailed studies were released showing how polluted Passaic River waters could be treated and used for industrial or residential purposes, while continuing to meet existing mill right lease requirements which persist to the present. The water company immediately demolished some deteriorated elements at the intake structures and replaced part of the adjacent towpath, as noted in Part II, but otherwise left most dam and intake components in their original state prior to the hydropower facility lease. Hackensack Water Company ownership changed in 1983 and 1984, but the company continues to be directly responsible for management of DWPLC assets (Herald News, September 16, 1947, October 19, 1983; Anonymous, n.d.; Hackensack Water Company [primary sources]; personal communication, Gisele Bryant).

PART II. DESCRIPTIVE INFORMATION

General Character and Condition of Canal and Canal Structures

Beginning at its dam and intake structures, the Dundee Canal remains an open waterway for about 6,100 feet through Clifton and to a point about 300 feet north of Monroe Street in Passaic. The next 2,200 feet of the main or upper canal to Passaic Street comprise the section placed in concrete culverts by the city of Passaic in the 1930s and subsequently covered by asphalt or concrete. About 500 feet of open waterway then reappear, extending to the sharp angle at the bottom of the main canal, where the last 1,200 feet running to the east disappear again under concrete. The lower canal or tailrace is covered by, and evidently encased in, concrete from an undocumented construction episode. Along its upper open section, the canal water surface is 75 to 100 feet wide between relatively intact banks. Most of this section north of Ackerman Street in Clifton is wooded. Further south along the open section, industrial and commercial development characterizes virtually the entire west side, with the east side marked by similar but less continuous development and by landfill abutting the Passaic River. The shorter open section north of Passaic Street has a far more deteriorated profile, with demolition and other debris nearly filling the canal. Refuse of varied type and size appears along the upper open section as well.

All Dundee Canal structures except the uppermost ones at the dam remain undocumented, including any buried remains of the lower locks, the intake of the Acquackanonk Water Company, the lower flume(s) or culvert of the main canal to the Passaic River, the channel created in lower Weasel Brook for the canal tailrace, numerous intakes and tailraces at the industrial sites which use or used Dundee Canal water, and road or rail bridge crossings.

Immediately prior to demolition actions associated with hydropower facility installation, the dam, headgates and guardlock remained in generally good condition. The cut sandstone dam of 1859, with its stepped downstream face, remains a highly visible landscape feature. Early 20th century alterations lowered part of the eastern lock wall and added a concrete spillway below this wall section, but left intact the masonry lock and headgate walls which probably dated to canal constructions of c.1859-60. The inoperable mitre gates at the upper end of the lock, built in 1903, reproduced both the approximate form of the original gates and the canal company's failure to install similar gates at the lower end of the lock. The inoperable headgates adjacent to the lock retained their approximate original dimensions and arrangement, although the vandalized and burned gatehouse was replaced by a timber walkway in the 1970s, leaving only notches in the masonry to mark the locations of original gatehouse deck support timbers. Along the west side of the headgate structure, most of the masonry training wall is gone, and the rubble masonry wall immediately below these gates to the west is deteriorating (Photographs 1-15).

Little of the original canal prism remains below the intake structures within the hydropower project area. Erosion or flood damage evidently lowered most of the western bank decades ago, while more recent sheet piling removed most of the eastern bank. The wastegate structure in this latter bank became a concrete-enclosed pipe in the 1970s, located just above a sewer passing under the canal and through the eastern bank in a sheet pile cell. In 1975, the Hackensack Water Company demolished a frame gatekeeper's house and an associated outbuilding, located on Randolph Avenue and probably contemporary with guardlock and headgate construction (Figure 3).

Original Design and Construction of the Completed Dundee Canal

The Dundee Canal, built between 1858 and 1861, functioned well for several industrial purposes, but it was an improbable means of navigating up the Passaic River, regardless of the original intent of its promoter and designers. As built, the stepped dam which marked the beginning of construction retained an enlarged Dundee Lake with a normal water surface of about 26.5 feet above mean sea level. (Elevations used in this report derive from 20th century data found on maps and plans made by the Works Progress Administration 1936; Howard Needles Tammen & Bergendoff 1982; the U. S. Geological Survey 1955, 1981; and the Dundee Water Power and Land Company 1918. J. W. Allen's 1858 description of a 22-foot fall between dam and river reflected the approximate fall to high tide.) The intake structures, probably completed c.1859-60 in conjunction with dam construction, evidently maintained a normal water surface elevation in the uppermost canal of about 24.5 feet, with this surface 75 feet wide across the lock and headgate structures described below (the canal surface elevation observed in October and November of 1985 was slightly over 25 feet). In any navigational sense, the upper lock was a guardlock between Dundee Lake and the canal, although in the absence of a lower mitre gate, never installed, it simply helped regulate flows to a power canal. J. W. Allen's original design plans called for a fall of 2.5 inches per mile, but the same water elevation usually pertained at the junction of the constructed upper canal and the proposed double locks about 1.3 miles below the dam, south of Jefferson Street in Passaic. The upper canal to this point and probably for the remaining half mile of its length was completed in c.1860-61, thus maintained a normally level slope well-suited to boat traffic. The intended fall, designed by a railroad engineer, was excessive for any such traffic headed upstream and was not implemented. This slope also delivered very little fall for power, restricting perceived water-powered industrial sites to locations between the upper canal and the level of the Passaic River. The Dundee Manufacturing Company took immediate steps to augment its waterpower sites by extending the lower end of the upper canal about 1,200 feet east of the original terminus, as anticipated by Allen's original plan. However, the company intended its best sites to be between the upper and lower canal, in an area where the first manufacturers actually located on the system, beginning in 1862. It was in its management of lower Weasel Brook as a combined tailrace and navigation canal that the company constructed, by intent or lack of engineering finesse, a canal system unsuited for navigation. The locks linking the upper and lower canals were technical failures, and the level of the lower canal was evidently too high to allow for boat traffic except in exceptional high tides, given the absence of any attempt to regulate water levels at the mouth of the brook. The lack of a mitre gate at the guardlock, although clearly an impassable obstacle to any downstream traffic, became a moot technical feature in regard to upstream traffic, since no boat was likely to rise above Weasel Brook to find its way to the blocked lake (Allen 1858; Dundee Manufacturing Company 1858 [drawings]; Dundee Water Power and Land Company 1918, n.d. [drawings]; Scott 1922: 271).

The Dundee Manufacturing Company began two wooden locks at the junction of the upper and lower canals by c.1860-61, arranged as a single flight. Each lock was about 110 by 25 feet in the clear, with a 12-foot rise. Both lacked the pile foundations needed in the soft bottoms of the Weasel Brook valley, and the lower lock remained incomplete. Passage of any boat headed upstream through this junction seems historically unlikely. The company also never removed the coffer dam built for lock construction, although its location and effects on navigation remain unknown. Lower Weasel Brook evidently remained at best marginally navigable to the locks after canal construction ceased in c.1861, a condition which was probably the principal impediment to any Dundee Canal transportation possibilities. Although the company channelized the brook below the lock site, creating undocumented, probably vertical banks. Contemporary observers considered the 50-foot-wide channel too narrow for navigation. The canal widths found in both the upper canal, as constructed, and in the 1858 charter amendment exceeded this figure by at least half. The depths or elevations reached in the channel were probably insufficient to allow at least four feet of water at all times, even with water entering the channel from Weasel Brook above the locks. The flight of locks, in theory, dropped to a normal water elevation of about mean tide. Unless the company excavated and maintained a channel at least four to seven feet below low tide at the canal/brook mouth, boat traffic at low tide in most seasons would have been extremely difficult in the system as built. No plans called for additional guardlocks which, at the river and perhaps supplemented by gates where the brook entered the lower canal, could have maintained sufficient lower canal water levels. Guardlocks could also have interfered with mill privileges on Weasel Brook. All documentary and inferred evidence suggests the company built the lower canal only as a tailrace (New Jersey State Supreme Court 1882; U. S. Army Corps of Engineers 1884, 1899; Dundee Water Power and Land Company 1918 [drawings]; Scott 1922: 271).

In c.1860-61, prism construction in the upper or main canal created water surfaces at least 75 feet wide between the dam and Passaic Street, below which point the canal narrowed in several stages to a 30-foot width at the point where the culvert dropped the lowest water into the river around Fifth Street. Field investigations undertaken for this documentation, as well as available topographic maps, indicate that prism construction from the dam to at least Sussex Street in Passaic involved building artificial towpath banks on the east side of the canal, using material excavated from natural glacial terraces to the west above the river. This method, using modified natural surfaces as one of two required banks, featured prominently in 19th century American canal engineering and usually provided the cheapest initial construction costs in an epoch of hand- and horsepowered methods. On more level terrain, apparently characterizing most of the upper canal below Sussex Street, more costly construction of two banks and/or excavation of a complete prism became necessary. Canal width above Sussex Street varied with the desired canal bottom elevations and the sinuous edges of the terraces, exceeding 250 feet at two points in what appear on the earliest plan of the proposed canal as possible boat basins. The locations of these wide spots, far from either lockage point where such facilities were often needed on narrow contemporary navigation canals, tend to belie this function and suggest instead a simple adaptation to terrain. As completed, the upper canal had a nominal seven-foot water depth (10 feet in the rebuilt older section of c.1933), with banks at least nine feet above the minimally 60-foot-wide prism bottom (Dundee Manufacturing Company 1858; Lindsey 1873; Dundee Water Power and Land Company 1918 [drawings]).

The upper half mile of the completed canal followed the route of the earlier power canal built c.1833. Since the earlier canal was evidently deeper and narrower than the later one, the prism construction of c.1860-61 probably included additional excavation in slopes on the west side of the canal. The artificial bank on the east side was generally just above active floodplain, which together with the expense of demolishing and rebuilding this bank, probably ruled out widening the canal to the east. Field investigations for this documentation suggested two episodes of side-hill cutting, perhaps corresponding to the first and second periods of canal construction, as discussed below.

Most other details of original or later construction remain undocumented below the intake structures. Except for a wastegate just below the guardlock, there were no other channels to the river above the tailrace and the outlet at the end of the upper canal. No streams requiring structures for intake or avoidance (feeders or culverts) crossed the canal.

Intake Structures and Uppermost Section: Siting and Original Construction

The Dundee Canal dam and intake structures consist of three components: the 450-foot-long dam across the Passaic; the guardlock adjacent to the dam's west edge, 148 feet long with a clear width of 25 feet; and an intake channel on the west side of the intake complex, 44 feet wide and 125 feet long, sharing the guardlock's west wall and equipped with nine gates divided by a stone pier. The two intake structures have a total width of about 78 feet from the east side of the lock wall, abutting the dam spillway to the west side of the intake channel. This documentation encompassed the two intake structures and the adjacent 200 feet of canal to the south, in the area subject to radical alteration or demolition during hydropower installation, with additional investigations on the west edge of the dam and along about 120 feet of canal prism further south (Figure 3).

Passaic Formation sandstone underlies all the canal features just noted at present elevations ranging between approximately 7 feet beneath the toe of the dam to about 31 feet beneath the slope above the west edge of the canal. The bedrock was high enough before dam construction to create a series of rapids beginning at the dam site, and running several hundred feet to a slackwater area which became an important ford during earlier historic and probably prehistoric times. The dam and intake structures rest directly on bedrock, probably modified during construction. Bedrock modifications during adjacent prism construction remain more ambiguous but, as described below, stratigraphic data collected for this documentation suggest most such construction in the area studied did not require removal of bedrock. Original dam construction and repairs made after 1870 involved some bedrock excavation where the lowest of the present 18 1-foot-high, cut sandstone steps in the toe meets the river bottom. Backed by a rubble masonry core, the stepped spillway rises to an elevation of 25.4 feet at the 4.5-foot-wide crest. The under-documented upstream dam face apparently includes a vertical masonry wall about 13 feet high, backed by earth fill originally sloped at 2 or 3 to 1, with subsequent flattening by siltation. Flashboards about 16 inches high formerly maintained Dundee Lake at its normal elevation. An iron plaque, 18 by 12 inches and set into the cornerstone at the west edge of the eleventh spillway step from the top, names the men serving as Dundee Manufacturing Company directors when the dam was dedicated in 1859 (Figure 3; Photograph 16; Lindsey 1873; Works Projects Administration 1936 [drawings] partly reproduced in Photograph 17; Harris-ECI Associates 1978; Petroleum Exploration Society of New York 1981).

Guardlock Construction

Twentieth century drawings and controlled probes made during documentation fieldwork indicate that most of the guardlock chamber between mitre gate locations has a levelled bedrock bottom with an 11-foot elevation. Beginning about 8 feet south of the existing mitre gate centerline, the lock bottom rises 4.5 feet in two or three steps, continues north at this higher elevation to the downstream edge of the closed gates, and apparently drops 1.3 feet to a level running under the gates and north to the end of the lock. Bottom configuration at the lower end of the lock remains undocumented. Silt, sand, running water, and recent cultural deposits obscure virtually all lock bottom surfaces. Relatively soft-bottomed canal deposits south of the lock precluded deployment of equipment able to expose either these surfaces or lock wall footings during field documentation. The mortared, dressed ashlar lock walls rise from a prepared bedrock surface probably no higher than the lock chamber bottom. Each wall originally rose about 17.2 feet above the lock chamber bottom, south of the upper gate site. Except at the 15-foot-long, 1.5-foot-deep quoins recessed into the lock walls to receive open gates, the east and west lock chamber walls are 5 and 4 feet wide, respectively, with a rough-faced return at the south end of the east wall meeting the former edge of the earth canal prism. Beginning about 12 feet south of the present gates, the lock walls originally rose three feet above the chamber walls by way of sandstone block steps. At the higher wall elevation from the gates north, pairs of iron tie bars link the upper stone joints for added strength against Dundee Lake's water pressure. The apparent history of gate construction, outlined below, suggests that the extant tops of ashlar lock walls represent original construction (Figure 3; Photographs 2, 3, 4, 5, 8, 9, 10, 11, 12, 13; Society for Establishing Useful Manufactures 1903 [drawings]; Works Projects Administration 1936 [drawings], as reproduced in Photograph 17).

Contemporary accounts and the absence of any signs of gate hardware or associated masonry alterations confirm that neither the Dundee Manufacturing Company nor its corporate successors ever installed gates at the lower end of the lock (U. S. Army Corps of Engineers, 1884, 1899; Photographs 4, 5, and 8). The company originally installed mitre gates at the upper end of the lock, probably each 14.5 feet long and about 16.3 feet high, judging from present gate configuration, with a total of 24 paddle gates. Paddle gates usually served to fill navigation canal locks and to hasten downstream lockage but, in this case, they never served such a function, although the company retained this means of letter water into the canal. A later company treasurer noted that these gates could swing, and outlines of gatepost fittings in present masonry bear out this assertion. The original gates rotted and were replaced in 1903 as described below, leaving no known traces (Clayton 1882: 382; letter, E. L. Gardiner to W. Hughes, December 7, 1903 in Commission to inquire...1912: 10-11; Photograph 12).

Additional features of original guardlock construction probably included a mitre sill below the gate, and a walkway or bridge above the sill across the tops of the lock walls, analogous to the presumably later sill and walkway documented below. There is no information on the nature of these original features, although it is possible that some of the documented timber sill members were part of original construction.

Headgate and Intake Channel Construction

The masonry components of the headgate and intake channel probably date to original construction; all appear, or are implied, on the earliest map of the completed canal (Lindsey 1873). The east side of the channel is the west side of the west guardlock wall, left rough-faced except above the headgates. Most of the west side is an unmortared rubble wall, built to maintain a vertical face along the abutting cut slope, and originally about 15 feet high above the cut bedrock surface apparently running under the lock chamber and at least part of the intake channel. The northwestern end of the channel at the headgates is a different structure, similar in height and composition to the guardlock wall, with a smooth surface and a return at the junction with the rubble wall. A mortared rubble training or wing wall, originally about 87 feet long and three feet high, ran northwest of the headgate structure on abutting ground (Figure 3; Photographs 1, 3, 6, 7, and 13; Works Projects Administration 1936 [drawings], as reproduced in Photograph 17).

A mortared smooth-faced ashlar pier, 20 feet long and 4.5 feet wide, rises about 18.4 feet above the apparent intake channel floor elevation. Running parallel to the channel walls as shown in Figure 3, the north half of the pier served as partial framing for the headgates and supported part of the gatehouse. Perhaps five gatehouse floor beams, up to 15 by 8 inches in size, once rested in notches built or cut into the top of the pier, with the southernmost beam running across the intake channel and the full width of the pier (perhaps in two sections) to corresponding notches in the channel side walls, and other beams similarly oriented but set into smaller notches on the upper sides of the pier (Figure 3). The former gatehouse, a gable-roofed frame structure about 14 by 45 feet, appears on all historic maps or plans of the intake structures, beginning with Lindsey's 1873 map (Photographs 7 and 14).

No available documentation pertains to the headgates proper, a bit of negative evidence which, given surviving information on changes to other parts of the guardlock-headgate complex, leaves open the possibility that much of the hardware present in 1985 dated to original construction. The documented complexity of the headgates and their attachments to intake channel masonry, viewed in context of the relatively large number of surviving Dundee Canal drawings, further suggests that unless the company replaced the gates within a few decades of original construction, the documented gates retain original configuration and at least some original members of components. Otherwise, some surviving alteration drawings would be expected.

There were nine gates, each four feet wide, running across the intake channel, with the masonry pier dividing the gates into two groups of four and five (Figure 3). Each gate visible in 1985 was a three-section piece of 1-inch-thick iron, apparently 10 feet high. Silt, debris, and water made access to gate bottoms extremely difficult, requiring some inference and comparison of elevations with the more accessible lock gate sill. When closed, the gates rested on a bedrock sill evidently continuous with that of the lock mitre sill, at an elevation of about 15.5 feet (visible in Photograph 14). The gates ran in 11 vertical, grooved iron guides, all of similar cross section but of varied heights and attachments to headgate and masonry elements. Each guide cross section was 7.5 by 3 inches, with the long sides perpendicular to the array of gates, and with three 1-inch-wide grooves running the full height of both guide surfaces to guide two adjacent gates in the middle grooves (Photograph 15). Each extreme end of the full gate array had one guide bolted into vertical channels cut into the masonry intake side walls, running from the top masonry surface to the bedrock sill about 15.8 feet below; maintaining common lengths for these two guides required, adding a single sandstone block to the height of the west intake wall (Photograph 14). A similar guide about 14 feet long bolted to each of the northwest and northeast masonry pier corners formed the other ends of each group of gates. The remaining seven guides, each about 14.8 feet long, apparently stood bolted to both the bedrock gate sill and to a lower bedrock surface to the south, continuous with the lock chamber bottom elevation with at least the latter connection made through diagonal iron braces (Photograph 14).

The iron guides supported a timber bulkhead on top of which rested the gate-raising mechanisms (Photographs 13 and 15). Two surfaces of 12 by 6-inch boards, set edge-to-edge vertically, rested on cast-on, 5-inch-long saddles projecting up- and downstream from each iron guide, with the saddles and bulkhead bottom at an approximate 25.3-foot elevation. When closed, the gate tops were slightly higher, forming a continuous but not watertight front to the lake. The boards rose above all intake channel masonry and about 1.6 feet above most of the iron guides, requiring several types of bulkhead fastenings: 1-inch-diameter spikes driven vertically through the boards; .75-inch-diameter tie bolts also run vertically through the uppermost boards; horizontal 5-inch-diameter tie bolts between timbers above the iron guides; and horizontal .75-inch-diameter tie bolts securing each timber below the guide tops to the guides. The latter connection was made through 6.5-inch-long, 2-bolt-hole flanges cast on to the guides, projecting from all guide edges parallel to the timbers at staggered 17-inch intervals (Photograph 13).

Two 12 by 12-inch timbers, morticed into the intake channel walls and the pier, span the downstream face of the gates immediately below the timber bulkhead. With diagonal bracing of similar-sized members morticed into the channel walls, these timbers added strength to the masonry framing elements of the headgate structure (Photograph 14).

Hand-powered iron reduction gears, on 1.75-inch-diameter shafts resting in iron saddles bolted to the bulkhead timbers, moved the gates via 8-foot-long iron stems set over the gate centers at 4.25-foot intervals. Each stem, 2.75 inches wide with teeth on two-inch centers, made undocumented connections with the gates. Surviving gears moving the stems included 3-inch-wide, 6-spoke, 23-inch-diameter wheels to act directly on the stems (Photograph 15). When fully open, the headgates probably rose a maximum of about 5.5 feet, creating openings with water surfaces 22 feet square.

Prism Construction

The Dundee Manufacturing Company confronted two related topographic problems when building the canal prism south of the intake structures c.1860-61: riparian terrain south of the dam, and the existing of the earlier canal built c.1833. South of the rapids at the dam site, the original post-glacial Passaic River floodplain widened somewhat, and the river turned slightly east in a shallow ox-bow with a tendency to erode the east bank, and to deposit sediment on the west bank where the current moved more slowly. Flood deposits and other river-borne material created a low-lying area of increasing width south of the dam site, ranging in elevation from the river up to between 25 and 30 feet. Short steep slopes above the latter elevations, carved out by late glacial runoff against the uneven bedrock surfaces, rose to more level surfaces above 40 feet. In the area studied, the visible or probable pre-canal lowland below 25-30 feet ranged between about 150 and 300 feet in width (Figure 3).

Dam heights of the two canal projects created constraints on water surface elevations, in turn requiring somewhat different prism designs for the lowland immediately south of the dam site. The dam of c1833 had a crest at elevation 17.5, eight feet below the dam of 1859. Normal canal water surfaces prior to c1860 would have been no higher than the impoundment level, with the canal bottom at least a few feet lower. Lata from soil cores, taken in the de-watered prism remains of the project area during documentation, suggested a probable canal bottom of disturbed loam overlying remains of a loamy sand subsoil beginning at about elevation 15.6. The virtually constant 27.3-foot elevation of the east canal bank or towpath, within and immediately south of the project area, is thus about 11.7 feet above this apparent canal bottom. These data further suggest that the towpath and at least some of the adjacent canal bottom date from the first rather than the second canal project: the elevations just noted fit fairly well with the 12-foot depth of both the c1833 canal and the c1860 canal to the former's southern terminus, and with a minimal depth of a canal bottom below an impoundment at elevation 17.5. The two-foot depth of water defined by these elevations for the first canal (or slightly more, if the 1833 dam had flashboards) would have been inadequate for navigation, a function not mandated before 1858. The 12-foot prism depth of the first canal may reflect concern with flood protection, or perhaps early plans for an eventual combined navigation and power canal with a higher dam, consistent with J. W. Allen's 1830s plans for the 10-foot water depth achieved after 1858 in the first half mile of the later canal. This latter conjecture would assume more connection between the Atterbury interests and the early DMC Pompton interests than was suggested above in Part I (Figure 4; Scott 1922: 270).

Scott's remarks comprise virtually all the documentary evidence on the size and location of the first canal prism, leaving the width and consequent construction problems unknown. Soil cores taken on the west bank south of the project area during field documentation indicated two distinct strata of fill in some places, suggesting that the second canal may have been wider than the first and involved excavation of the latter's original slope (Figure 4). Although these data could also reflect an undocumented episode of later maintenance dredging, the stony nature of the fill strata probably reflects removal of original subsoils rather than silts and sands deposited in an existing canal. The towpath location suggests that the first canal builders, required to excavate a canal bottom at least several feet below the dam crest, avoided the steeper edges of the floodplain terrace and kept as far east as possible without dropping into the active floodplain. As the slope became lower and more gradual, less excavation was needed to reach the desired elevation. Thus, the low dam of c1833 may have vitiated the advantages usually sought by canal builders in natural terrace slopes, whereby cutting into such slopes created one prism side. Here, building the first canal may have involved creating artificial embankments on both sides, with the west bank consisting of excavated material deposited and shaped on the natural slope. The second canal, probably a wider structure to accommodate the new navigation mandate, would under this hypothesis have required removing the earlier artificial slope of the west bank while retaining the towpath intact. Neither documentary nor field data indicate puddled lining or stone embankment features such as riprap for either canal in the area studied. The observed 12-foot vertical distance between towpath top and probable canal bottom also suggests that, at least in the transect studied, prism construction did not require bedrock excavation (Figure 4).

Changes after c1860 to Intake Structures and Uppermost Prism Sections

Gatekeeper's House

The Dundee Water Power and Land Company built a gatekeeper's house between c1873-77 on present Randolph Avenue between Van Riper Avenue and Homcy Place, opposite the canal several hundred feet below the intake structures. Evidently modified several times, the gatekeeper's house was originally a 2-1/2 and 1-1/2 story, ell-shaped frame structure with a round turret at the outer corner; the plan as shown on one insurance map suggests a Queen Anne-style arrangement, although no photographs have yet surfaced. The site eventually included a 1-1/2-story barn with lower appended sheds and a small greenhouse. The Hackensack Water Company demolished all standing structures on this lot in 1975 (Lindsey 1873; Hyde 1878; Clayton 1882: 382; Robinson 1901, 1916; Sanborn Map Company 1935; Globe Wrecking Co., Inc., to Dundee Water Power and Land Company, January 1975, in Hackensack Water Company [primary sources]).

Wastegate

Descriptions and plans of the canal projected in 1858 included no engineering structures immediately below the guardlock and headgates, but by 1873 the canal company had installed a wastegate through the towpath about 95 feet south of the east guardlock wall, presumably to release water during very high flows or for canal maintenance-related draining. Limited descriptive and cartographic data indicate this was a wing-walled masonry structure about 15 feet wide and 20 feet long, with two sluice gates and perhaps a frame gatehouse. By 1935, a cinder block gatehouse sheltered the structure. A concrete-encased, 24-inch pipe replaced the wastegate structure c1978, and hydropower facility construction demolished and removed the site in October 1985, just prior to field documentation (Figure 3; Photograph 2; Lindsey 1873; U. S. Army Corps of Engineers 1900; Sanborn Map Company 1935; Works Projects Administration 1936 [drawings]; ECI-Harris Associates 1978; Dundee Water Power and Land Company 1978 [drawings]).

Guardlock

As the Dundee Water Power and Land Company became less concerned with maintaining any pretense of providing navigation facilities, it transformed the guardlock into a structure which evidently served primarily to control canal water levels. By the early 20th century, the company lowered the west lock wall three feet between the mitre gate and the lower unused gate quoin to an elevation of about 25.2, and installed a 2-foot-diameter cast iron pipe through this wall about 33 feet south of the mitre gate sill. The pipe, installed at a bottom elevation of 15.2, and the low wall helped maintain the canal water surface at 24.5 feet during high flows. The pipe has a cast-on legend, M O N/ & P[or F] Co/1899, while the lowered wall appears as an existing condition on a 1903 plan to rebuild the gates. The elevation of the lowered wall seems to preclude its being an original feature, since even as a somewhat theoretical navigation structure, the lock required walls higher than the 26.5-foot lake level to pass boats upstream. This latter action retained the general form of the original gates, by then rotted, but made the gates fixed in a mitre position (Photographs 3, 4, 9, 10, 11, 12; Figure 3; Dundee Water Power and Land Company 1903a [drawings]; letter, E. L. Gardiner to W. Hughes, December 7, 1903 in Commission to inquire...1912: 10-11).

One preliminary plan for the gate rebuilding, dated before the flood of October 1903, included replacing the mitre form with a single timber barrier, perpendicular to the lock walls and containing 15 paddle or wicket gates. This and one other surviving 1903 design, as well as the slightly different one finally adopted, retained the paddle-type openings seen in the original gates as a means of equalizing water levels on both sides of the gates, although their precise function relative to the headgates remains unclear. The changes made to the east lock wall, which could be contemporary with the gate rebuilding, suggest that the entire chamber served as a flood control structure, created as such during a brief period of heavy flood damages in 1902 and 1903. The original gates were evidently in place until after the 1903 flood; their efficacy during that disaster remains unclear. Although the company's decision to build a mitred rather than a bulkhead-type gate structure is undocumented, conversion of the gates from swing to fixed mode may reflect concern with flood control, as well as some residual desire to preserve the cosmetic appearance of a lock structure in the context of the 1903 suit to compel opening of navigation (Dundee Water Power and Land Company 1903a, 1903b [drawings]; letter, E. L. Gardiner to W. Hughes, December 7, 1903 in Commission to inquire...1912: 10-11; Works Projects Administration 1936 [drawings]).

The gates built by December 1903 are evidently the ones removed in 1985, and conform with some modifications to those planned in November 1903 (cf. Photographs 10, 11, 12, 18). As built, the gates were each 14.5 feet wide, and about 18.4 feet high from the cut bedrock surface north of the gate sill to the top of the timbers supporting the wicket heads. All timbers framing the gates and forming a triangular stop on the sill to the south were 11 by 12 inches in section. The stop consisted of two timbers set against the two gates, a 24.8-foot timber spanning the lock chamber, and a 7.5-foot timber brace morticed and bolted into the longest member (Figure 3). Concrete or rubble filled the two spaces formed by the stop timbers. The two rows of gate openings, arrayed three over four and beginning two feet above the bedrock sill, were each 2.6 feet wide and 2.75 feet high. Each cast iron paddle gate consisted of a 5-inch-wide frame bolted to vertical framing timbers, and a movable panel .75-inch-thick, 2.25 feet wide, and 2.5 feet high with a central hollow to receive the wicket shaft. Three iron saddles, bolted to the top and bottom of each paddle gate frame and to the top of the timber gate structures, secured each of the 14 2.5-inch-diameter iron shafts set 1.75 feet apart on each gate, which swiveled the movable panels when turned by hand wheels. The uppermost saddles were bolted to the higher of two 5-inch-square timbers above the gate framing members proper, through the 9 by 2-inch timber sheathing covering the northern gate faces above and between the paddle gates. Iron angles, six inches wide and bolted to horizontal gate framing members above the paddle gate openings, supported planks into which some sheathing timber ends were nailed (Photograph 11).

The two 5-inch-square timbers also supported the northern guardrail of a deck built over and south of the angle of the mitre gates, consisting of 12 by 2-inch planks nailed to three 10 by 12-inch stringers set flush with the adjacent upper masonry surface. The deck extended 15 feet south of the gate angle. Although largely undocumented and rebuilt several times, the deck probably originated no later than the 1903 gate rebuilding episode, judging from the height of the wicket shafts. There was a second deck or bridge over the lower end of the lock in the 1930s, gone by the 1970s. The history of this feature remains undocumented (Figure 3; Photographs 10, 12, 13, and 17; Dundee Water Power and Land Company 1977 [drawings]).

After 1903, the only substantial changes or repairs made to the lock chamber involved the east wall, which in its lowered form served as a spillway. By 1936, the company had built a triangular concrete spillway 7-8 feet below the lowered wall, perhaps to check erosion of the adjacent river bank caused by water from the lock chamber. In its present form of concrete, ashlar block remnants, and sandbags, the top of the lowered wall reflects both water damage and undocumented repairs (Figure 3; Photographs 4 and 9; Works Projects Administration 1936 [drawings]; Dundee Water and Land Company 1977 [drawings]).

Headgates and Intake Channel

Prior to the demolition of the vandalized and burned headgate house in October 1974, there were no documented changes to this part of the canal intake complex other than the addition of an irregular, semi-conical, rounded, mortared rubble pier at the southeast corner of the intake channel. This later feature first appears on available maps in 1936. Its function remains unknown, but it may have served to support a weakening corner of the original channel wall. Sometime after 1936, the wing wall at the northwest corner of the headgate structure was shortened. A 5-foot-wide bridge of 12 by 3-inch plank nailed to two 12 by 12-inch stringers replaced the demolished headgate house c1978. By 1985, the partly burned and dismantled intake gates were blocked in closed positions by timbers wedged between the gate guides, and the western channel was partly collapsed. Hydropower facility installation in 1985-86 included rebuilding the top of the latter structure with stones removed from the partially demolished east intake channel/west lock wall (Figure 3; Photographs 1, 3, 5, 6, 7, 8, 14, and 15; Works Progress Administration 1936 [drawings]; memo, J. E. Butler to C. M. Millspaugh, Jr., October 10, 1974, Hackensack Water Company [primary sources]; Dundee Water Power and Land Company 1978 [drawings]).

Prism

There was no documented maintenance or alteration of the prism section in and adjacent to the project area prior to c1970. Profiles drawn in 1900, taken at 25-foot intervals apparently beginning at the intake structures, suggest varied amounts of siltation, but there is no record of maintenance dredging. The profiles of 1900 do not seem to match profiles recorded during field documentation at similar locations, even assuming extensive siltation in 1900. Ambiguities in the scale, location, and elevations of the earlier profiles remain unsolved. One section of the prism investigated in 1985 had over four feet of silt and sand deposits above the apparent original canal bottom. Comparison of Lindsey's 1873 map of the completed canal with some 20th century maps and atlases indicate that the west canal bank immediately below the intake channel had eroded by 1900, with the top of this bank nearly two feet below the opposite towpath. A sewer outlet installed under and through the canal c1970 included a steel sheet pile cell in the towpath about 40 feet south of the wastegate and two rows of similar sheet piling between the outlet and the wastegate to stabilize the intervening towpath. In 1978, sheet piling installation between the wastegate and the lock cut through and removed the lower edge of the inner towpath slope, in an apparent attempt to resist erosion of a very narrow section subject to both river and canal water forces. Hydropower facility installation removed this towpath section entirely in 1985, while associated installation of a temporary bypass pipe, between earthen coffer dams above the intake structures and below the facility site, further eradicated the west canal bank edge. The entire prism section in the project area was thus in extremely poor condition at the time of this documentation (Figure 3; Photographs 1, 2, 3, and 7; Lindsey 1873; Dundee Water Power and Land Company 1900, 1977, 1978 [drawings]; Robinson 1901; U. S. Department of Agriculture 1975).

PART III. SOURCES OF INFORMATION

Plans and Drawings

The Hackensack Water Company acquired all surviving original drawings held by the Dundee Water Power and Land Company in 1974, when the water company bought the DWPLC. This collection appears to be the largest one showing planned and as-built structures dating to 1858 or later. It includes some drawings made by other parties or agencies showing DWPLC properties, and a large number of drawings not reviewed for this documentation showing portions of the canal below the intake structures. The DWPLC name was retained on drawings made after the 1974 transfer. All items listed below come from this source; asterisked items appear as photographs made for this documentation.

Anonymous
n.d. Plan of Proposed Lock at Lower End of Dundee Canal in the City of Passaic, N.J. On file in office of Secretary of State, Trenton, NJ.

Dundee Manufacturing Company
1858 Map of the Dundee Manufacturing Company's canal between the mouth of Weazel (sic) Brook & Dundee Dam. Filed August 2, 1858 [presumably with Secretary of State's office], Tho. S. Allisin(?)

Dundee Water Power and Land Company
1900 Sections of Dundee Canal. September 22, 1900. Two sheets.

1903a Head Gates with 15 wicket gates. September 1903. [Original title, crossed out: Society for establishing useful Manufactures. Water Stop].

*1903b Lock Gate at Dundee Dam. November 1903. (title includes: Society for establishing useful Manufactures].

1918 Plans for Estimate of Cost of Locks from Weasel Brook to the Dundee Canal at Passaic, N.J. December 1918.

1977 Rehabilitation of Existing Inlet Works & Dundee Dam. Five sheets.
November 8, 1977. Prepared by C. Worischeck, P.E. for the Conduit and Foundation Company.

1978 Rehabilitation of Dundee Canal Dike and Headworks.
April 17, 1978. C. Worischeck, P.E.

Works Projects Administration, New Jersey
1936 Riparian and Stream Survey. Passaic River.

*1. Plan of Dundee Dam showing Structures-Sections & Elevations. Project 10-197. September 1936.
2. Untitled. Project ST-7C. October 14, 1936.

Drawings may be available for inspection, by appointment. Contact:

Hackensack Water Company
200 Old Hook Road
Harrington Park, New Jersey 07640
ATTN: Gisele Bryant (201) 767-1896

Interviews and Personal Communications

1. Edward S. Rutsch
   Historic Conservation and Interpretation, Inc.
   Box 111, RD 3
   Newton, New Jersey 07860
   (201) 383-6355

   Interviews and conversations October 1985-March 1986. Mr. Rutsch has directed industrial archaeological studies in the Paterson-Passaic area, and is currently conducting a study of Dundee Canal cultural resources relative to possible highway construction impacts.

2. Patrick M. Malone
   Slater Mill Historic Site
   P. O. Box 727
   Pawtucket, Rhode Island 02862
   (401) 246-1622

3. Gisele Bryant
   Hackensack Water Company
   200 Old Hook Road
   Harrington Park, New Jersey 07640
   (201) 767-1896

   Interviewed February 1985 and March 1986. Ms. Bryant is familiar with the recent legal history of the Dundee Water Power and Land Company and its successors.

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Hackensack Water Company
n.d. Miscellaneous collection of recent memoranda, recent in-house and consulting studies, and limited original corporate documents of the DWPLC.

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Given the dearth of surviving Dundee Manufacturing Company/Dundee Water Power and Land Company written records, additional research on these companies, their ownership, and their intentions during the 19th century would require considerable perusal of the following sources: land records, State of New Jersey court records, legislative documents, and materials filed with the Secretary of State; and records and minutes of the Society for Establishing Useful Manufactures held by the Paterson Public Library and the Passaic County Historical Society in Paterson. Contemporary newspapers in Paterson, Passaic, and New York City might yield useful summaries pertinent to corporate and local history, and perhaps to original conditions of Dundee Canal structures.

At least some open canal sections below the hydropower facility retain archaeological data on the adaption of the two types of canal prism (of c1860, and of c1833, altered c1860) to pre-canal land forms, as suggested in Figure 3 of this documentation. Reconstructing the full range of these data would require sampling at numerous relative points, using soil cores and/or machine-assisted excavation.

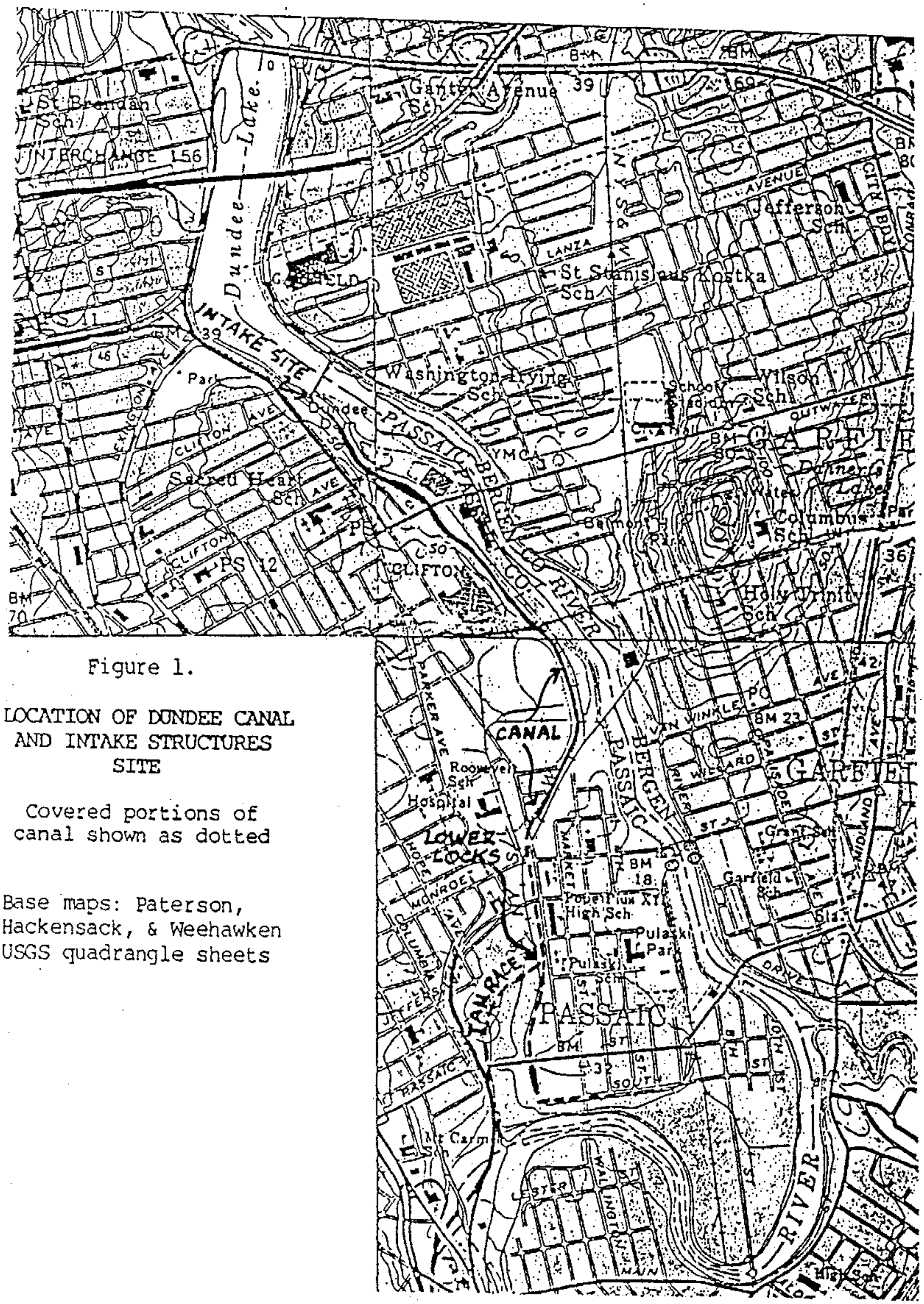

Figure 1.

LOCATION OF DUNDEE CANAL AND INTAKE STRUCTURES SITE

Covered portions of canal shown as dotted

Base maps: Paterson, Hackensack, & Weehawken USGS quadrangle sheets

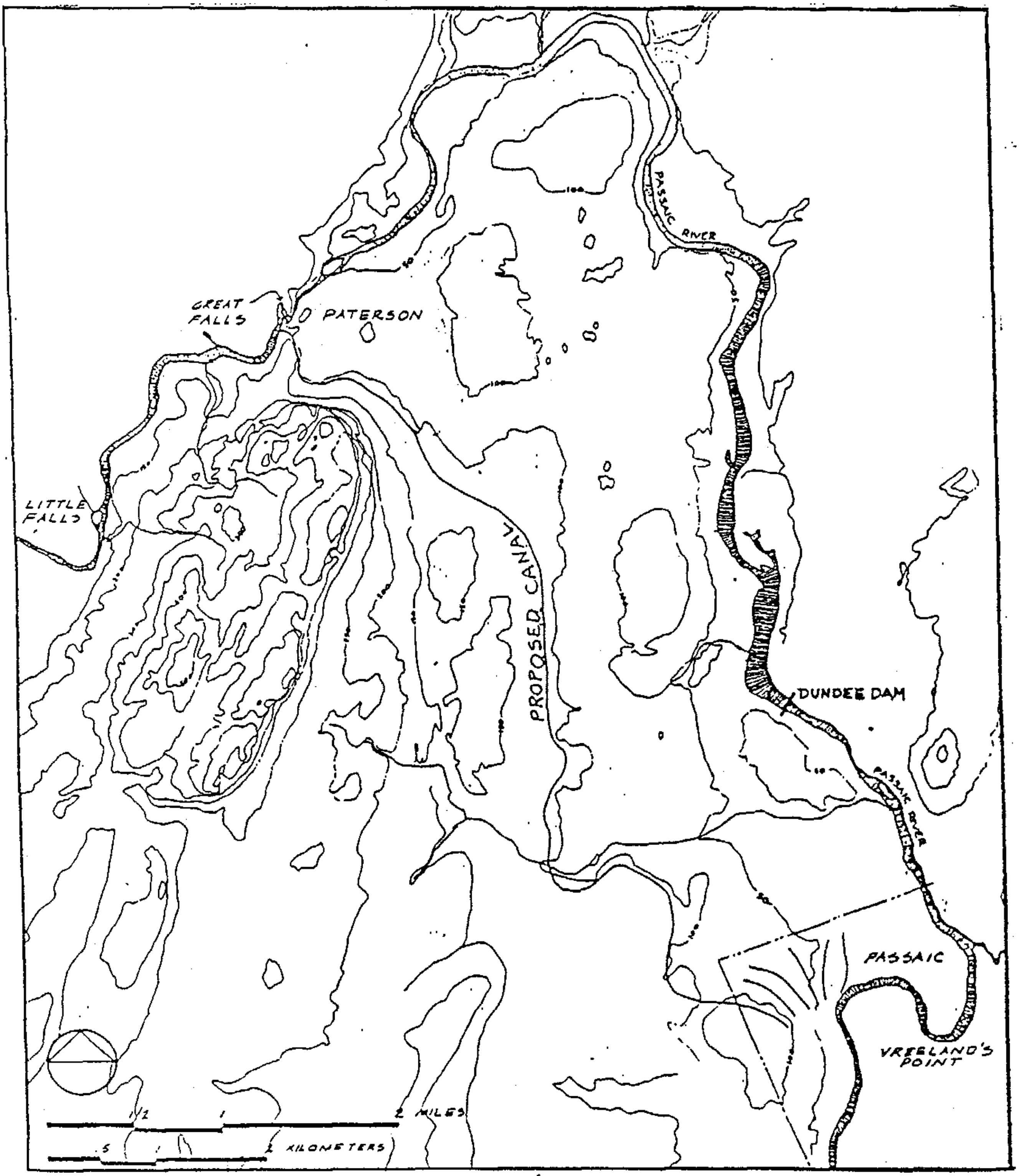

Figure 2. PASSAIC RIVER FROM VREELAND'S POINT TO LITTLE FALLS, SHOWING 1791-2 PROPOSED S.U.M. CANAL AND LATER DUNDEE DAM SITE

Adapted from map prepared for HAER No. NJ-1, reproduced in Fries 1974

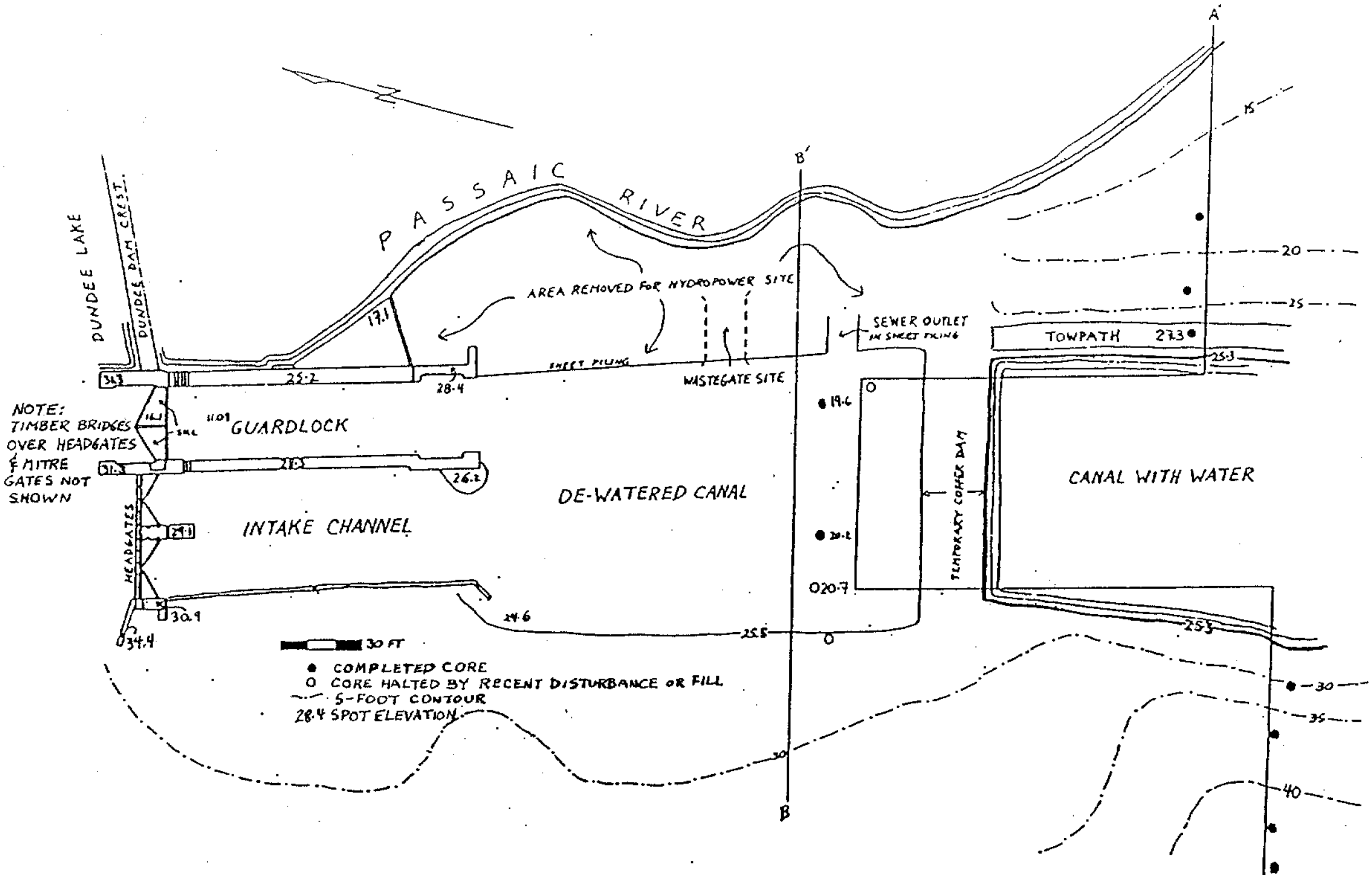

Figure 3. **PLAN OF DUNDEE CANAL HEADGATES, GUARDLOCK, AND UPPERMOST SECTION**

Because of the extremely poor condition of the canal prism in the study area, above the temporary coffer dam installed for hydropower facility construction, documentation techniques included sampling of two types of prism sections: canal bottom in the de-watered section above the coffer dam; and prism banks or towpath in relatively intact sections below the coffer dam. Sampling involved tests with soil augers 3-6 inches in diameter, driven to bedrock or refusal, in conjunction with locational controls established by transit survey. Profiles A-A^1 and B-B^1 appear in Figure 4.

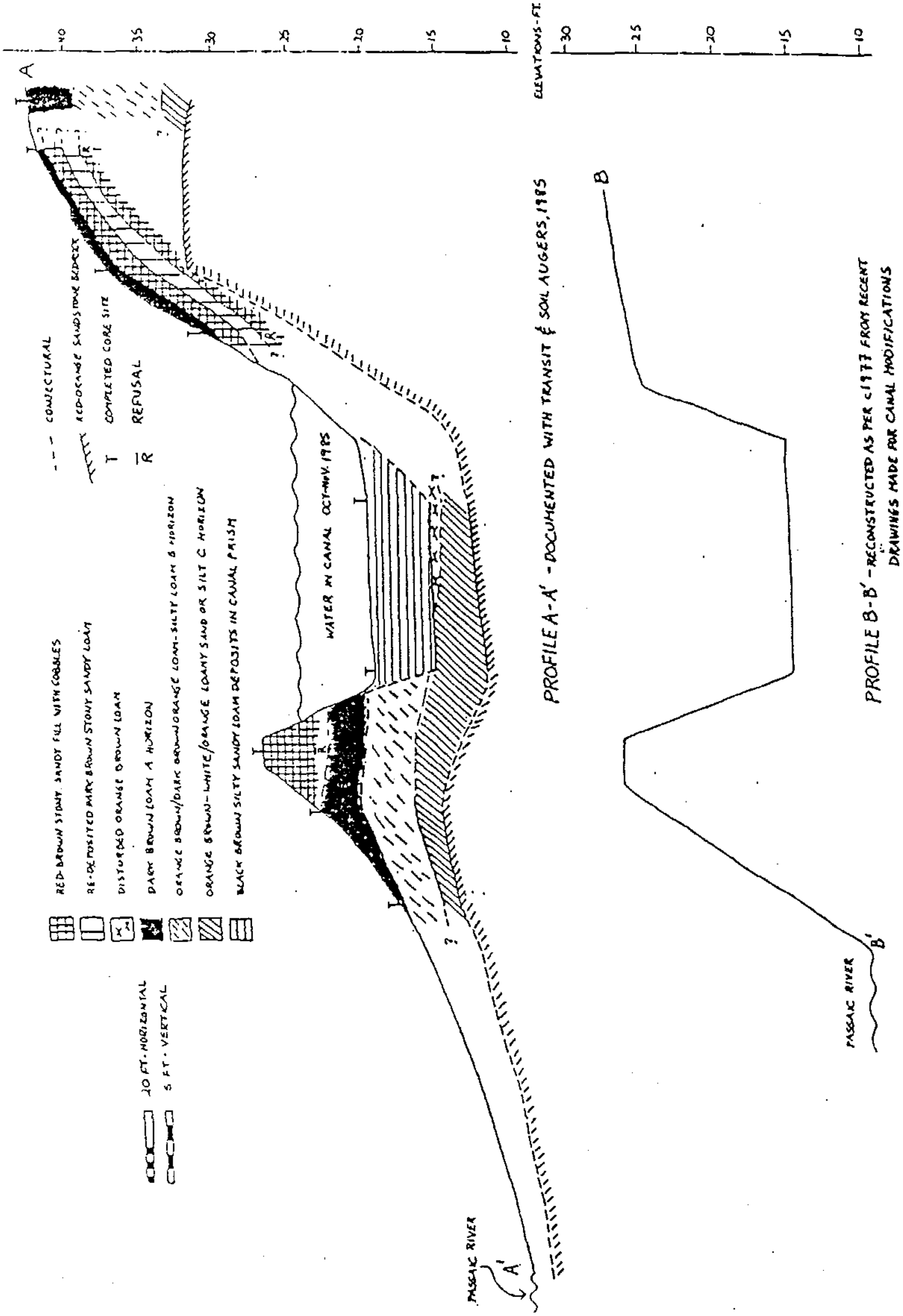

Figure 4. PROFILES $A-A^1$ AND $B-B^1$

KEY TO PHOTOGRAPHS